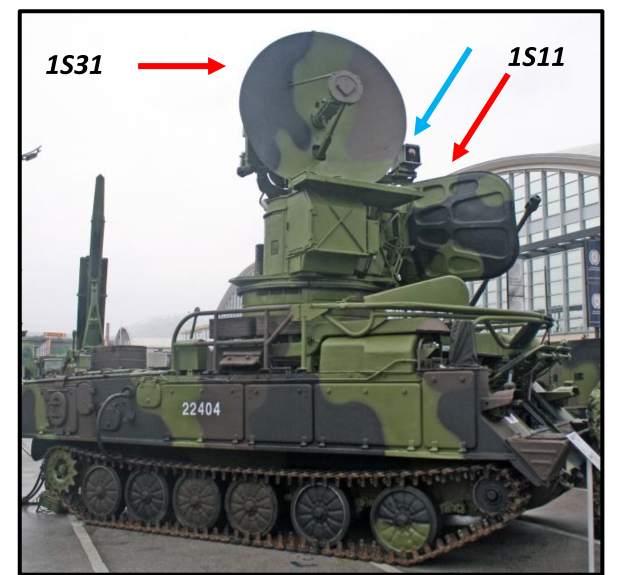
SA-6





The two main elements of the 2K12 Kub (SA-6 Gainful) system both are self propelled. 1S91 radar station and the 2P25 self propelled missile launcher.

The Kub was the division level SAM system of the Soviet armored divisions during the Cold War. Despite its role many NSWP motorized divisions got Kub regiments instead Osa (SA-8) regiments because of the delayed development of the Osa. Even after export of Osa many of these division kept SA-6 and SA-8 never was acquired for example in Hungary. Some NSWP countries used Kub as an interim solution as army level air defense instead 2K11 Krug (SA-4 Ganef) but some of them – for example Hungary – replaced with 2K11. Poland and Czechoslovakia even at the end of Cold War used on army level the Kub while at front level they operated full Krug brigades. (In Hungary the Soviet forces provided the front level air defense with Krug.)

The SA-6 is one of the most iconic Cold War SAM system thanks to its performance in the 4th Arab-Israeli (Yom Kippur) war where made a very successful debut in 1973. (In 1982 the Kub was much successful but not only because of its design.) The Kub was the first really medium range (today somebody calls it only short rage) fully mobile SAM system. All elements of the battery was self propelled on tracked chassis. From march the full readiness state could be reached within 5 minutes with trained crew.

The structure of the Kub system is similar to the homeland SAM systems but are some major technical differences because the 2K12 had to be designed fully mobile. One Kub regiment is built from one commanding battery and five missile batteries. For each missile battery is supported the 360 degree search/target acquisition capability as well as for SA-2/3 batteries but with the very long range target acquisition/EW radar was available only for the commanding battery.

The commanding battery had the P-40 target acquisition/EW radar as well as the PRV-16 height finder radar. The 9S416 KBU fire control cabin which forwarded the target coordinates to the missile batteries using data link. (Sometimes the Kub command battery got P-15/18/19 radar instead of P-40.)

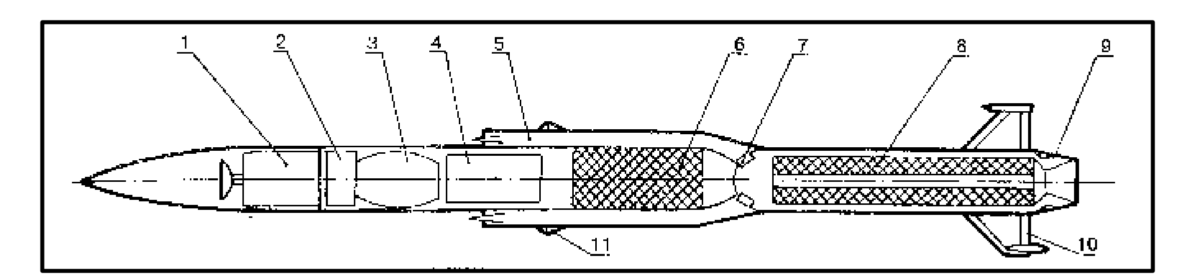
The 1S91 radar station (SURN) of the missile battery is equipped with two antenna systems. One of them is the 360 degree scan 1S11 target acquisition radar another is the 1S31 continuous wave target tracking/illuminator radar. The range of 1S11 against MiG-21 size targets is about 70 km the 1S31 has only 40 km range.

The missile uses SARH guidance but optical target tracking is also available similarly to SA-2/3. This optical tracking capability has real role only from 3M9M3 missile variant because of the SARH guidance itself. (The SA-2/3 used RCG). On the previous page the blue arrow shows the camera on the radar station.

Each missile battery has four 2P25 launchers each with three missiles and the 1S91 radar station (SURN). Because of the SARH guidance the system has only a single target channel but any missiles can be launched against a single target similarly to the S-200 Vega (SA-5 Gammon). The tracking method of the Kub was similar was designed to MiG-23. Using the coordinates from the commanding post or the 1S11 radar the 1S31 was set to the direction of the target then started the CW target illumination.

The engagement range of the 2K12 Kub was much smaller than the contemporary S-75M Volkhov (SA-2E) and even the S-125M Neva was superior in term of maximal engagement altitude. Considering the zone against real targets the maximal altitude difference had no impact at all in real tactical situations. The engagement zone of the Kub and Neva could be considered the same. In tactical environment targets almost never flew higher than medium altitude and only very rarely at high alt because in ‘60s and early ‘70s precision guided munitions (PGM) literally did not exist. Later the first of PGMs could be used only at low and medium level but literally all aircraft used unguided bombs and rockets none of bomber or attack aircraft could use their weapons outside of engagement zone of the Kub (only exception was the AGM-45 but it is suffered from the main lobe limitation)

Considering the flexibility and quick relocation capability with CW SARH guidance and better missile maneuverability the Kub was superior comparing to Neva (which was a PVO SAM system) As long as the missile engine was operational the turning capability of the missile was 15G which made a very serious threat any fighter in that time especially if they carried heavy stores.



1 1SB4M CW monopulse semi-active homing seeker with Doppler closure rate capability

2 3E27 CW radio two channel proximity fuse (30 m nominal radius)

3 3N12 57 kg blast-fragmention warhead

4 1SB6M Autopilot

5 Ramjet intake ducts

6 9D16K sustainer solid gas generator charge (67 kg LK-6TM reducing propellant)

7 Frangible seals

8 Boost stage solid propellant charge (172 kg VIK-2 propellant)

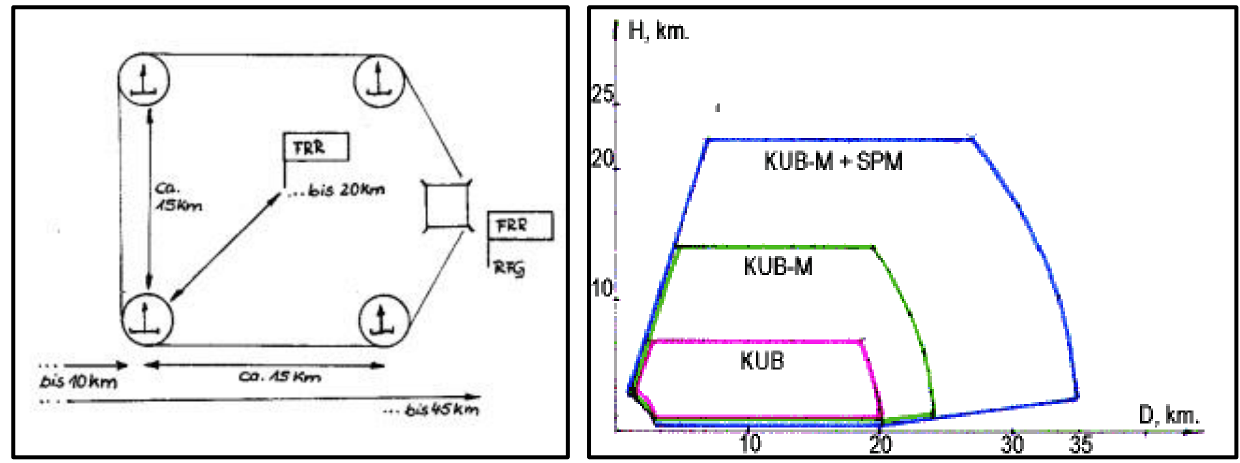
9 Exhaust nozzle

10 Cruciform tailfins

11 Cruciform wing

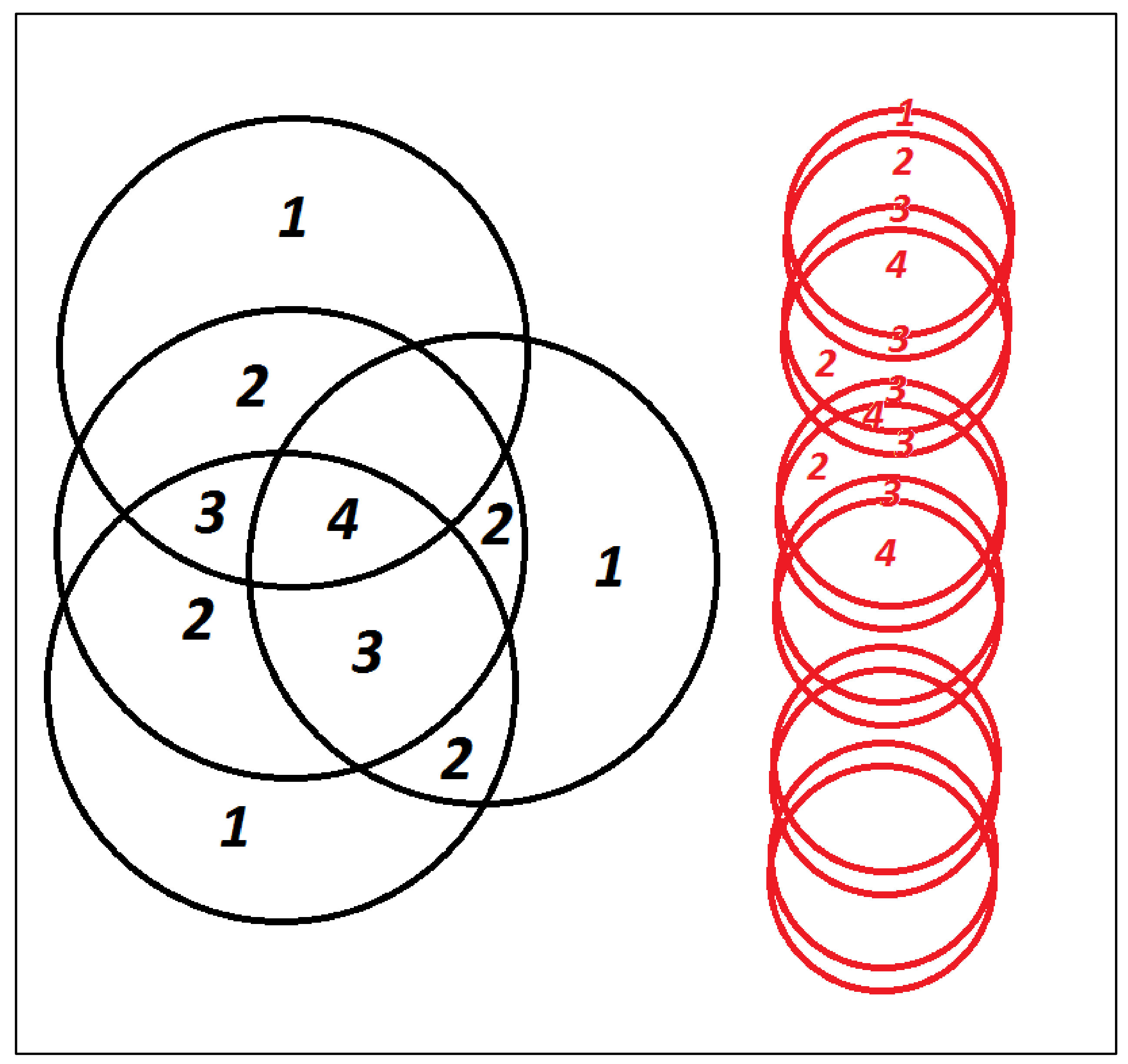
The launch weight of the 3M9 missile was 600 kg (comparing to VP-601P 5V27 missile of the Neva which was 952 kg) the propellant weight was only 172+67 kg (while for Neva this was 280+151 kg). The separation of propellant weight is justified by the construction of the missile. While the Neva had real two stages missile with jettisoned solid booster stage meanwhile the Kub has a much more advanced missile design.

The 3M9 missile was designed with separated engine chambers and not with jettisoned first stage. The booster engine ("8" on the drawing above) runs about 3-6 seconds and accelerate the missile up to 470 m/s (M1.5) then starts the sustainer ramjet engine ("6" on the drawing above) which is also used solid propellant (it was the first ramjet SAM in the world) it uses the oxygen of the atmosphere. Using this design approach it was possible to reach about 20 second of operation time for the sustainer engine only with 67 kg propellant. The top speed of the missile was about 900 m/s (M2.8). The weight of the warhead is 57 kg, maximal target speed is 600 m/s.



Above left is one of the used deployment method with four missile batteries and one commanding battery. (Most of the East Germany regiments had only four missile batteries instead five.) Above right is the engagement zone of the different variants of the Kub system with 0 km offset distance parameter. The Kub-M variant engagement zone is the definitive.

Besides of the many advantages of the ramjet engine it has some disadvantages. As the altitude increases the oxygen content is the atmosphere decreases therefore the thrust of the engine also decreases. Very likely this is the limiting factor in altitude for the engagement zone. Because of lack of PGM in that time this factor was so negligible that it could not be called a real disadvantage. It did not had serious impact (or at all) on capabilities. The engagement zone of Kub-M meant area denial capability against aircraft with dumb bombs and rockets considering the firepower of a single Kub regiment with five target channels. Even if 1-2 batteries performed relocation the rest three-four batteries could have large overlapping engagement zones. The total available target channel of a Kub regiment was considerably fewer (5 vs 20) comparing to a full Osa (SA-8) regiment but the defended are was larger and in some cases the "density" of target channels was higher.



Idealized comparison of the available target channel quantity of the Kub and Osa systems. 4 of 5 of Kub batteries are in deployed state 12 of 20 Osa vehicles of a full division are displayed. We can see depending on terrain locations the battalions (Osa vehicles are directly attached to fighting battalions) sometimes can be achieved better coverage with Kub sometimes with Osa. Because armored divisions got the Kub and motorized the Osa at least for Soviet armies both had to be considered.

With the 3M9M3 missile the Kub became capable to launch a missile without tracking and locking target with the 1S31 CW illuminator. Based on the coordinates forwarded by the IADS elements from commanding battery or optical tracking the missile can be launched toward to a pre-calculated impact point only in terminal phase has to be used the CW illumination. Using the feature it is possible to reduce strongly the available time for counteractions especially if the launch of the missile cannot be detected for example because is a cloud layer between the target and the SAM. Very likely this is how was downed the F-16 of Scott O'Grady in 1995 by the Serbian air defense.



On the launched missile are visible the closed inlets of the sustainer engine inlets with white colored plastic caps only after igniting the larger engine are they removed.

Considering jam resistance the 2K12 Kub was huge step forward comparing to all previous RCG SAM systems (S-75/125) because of the CW illumination and the monopulse seeker. (HAWK used the same guidance principle as Kub.) In 1973 the IAF did not try to jam the SURN because of the fear just making more easier to track jamming targets. The CW + monopulse made immune the Kub against the angle deception jamming which was usable against RCG SAMs without monopulse antennas (S-75/125). Of course the 1S11 target acquisition radar or the P-40 could be jammed made it harder to provide target coordinates for the missile batteries. The threat of the SA-6 could not be eliminated as level as was possible against older type of SAMs. The first real solution besides the VGPO type of jamming was the ALE-50 towed decoy but only after the Cold War the ALE-50 made its debut in 1999 during the Allied Force it saved many aircraft.

Regardless the Kub was very successful in Yom Kippur war in later conflicts gained much less trophies and sustained heavy casualties especially in 4th Arab-Israeli war but not because of the design of the system. The problem was as the Arab forces used the Kub.

After the Cold War some of the former WPAC members upgraded further their SA-6 but the level of upgrade was the same for every operators. The upgraded Hungarian Kub batteries are very likely the most advanced variants of the SA-6. Thanks to the upgrade they can be integrated the IADS of NATO systems such as HAWK or Patriot as a missile battery they can be acquire target coordinates from these or other radars in the digital data link system. The old camera replaced with a more advanced with night vision which makes possible tracking capability even at night. The CW illumination in terminal phase can be used even better than previously and not only at daytime.

Regardless te Kub system has older roots than 50 years it is widely used even today (2018). Of course in countries in the 3rd world got a different (degraded) export variant they called because of the 2K12 Kvadrat.

Hungary acquired the first SA-6 in 1975 and initially used as army level air defense unit (in Keszthely). From 1981 it was replaced with 2K11 Krug therefore the Kub batteries were sent their original organization level to the divisions in first echelons. Hungary acquired five Kub-M1 and 6 Kub-2 batteries later all were upgraded to M3 configuration.

Both Soviet armored divisions in Hungary were equipped with 2K12 Kub in Szentkirályszabadja and Komárom locations.

Finally here are some reference materials and video about the 2K12 Kub.

http://www.ausairpower.net/APA-2K12-Kvadrat.html
https://www.youtube.com/watch?v=Dmgn3RWXQUk
https://www.youtube.com/watch?v=y1qCOfQjAQU
https://www.youtube.com/watch?v=OdDAtHumZeg

Below is the 2K12 in strongly upgraded configuration.

https://www.youtube.com/watch?v=5kLBEhXHU24